California High-Speed Train Project

Request for Proposal for Design-Build Services

RFP No.: HSR 11-16
Structures Report
Ave 17 to Veterans Blvd

Prepared for

CALIFORNIA
High-Speed Rail Authority

CALIFORNIA HIGH-SPEED TRAIN

Engineering Reports

Record Set
15% Design Submittal
Merced to Fresno Section

High Speed Train Structures
Advanced Planning Study

May 2011

CALIFORNIA
High-Speed Rail Authority

U.S. Department of Transportation
Federal Railroad Administration

1.0 Introduction

1.1 California HST Project Background

The California High-Speed Train Project involves design and construction of a new high speed rail line connecting northern and southern California via the Central Valley. The initial phase will provide service from San Francisco to Los Angeles and Anaheim. Future extensions will be constructed to Sacramento and San Diego. The project includes passenger stations as well as various facilities for storage and maintenance of rolling stock and right of way maintenance and systems.

Within the Merced to Fresno Section, more than 60 miles of new rail line, two passenger stations, a maintenance-of-way facility, and potentially a heavy maintenance facility (HMF) is planned. The Merced to Fresno Section Maintenance Facility Technical Report provides important information related to the potential location of these maintenance facilities.

The project between Merced and Fresno is described in Section 2. As an overview, there are two primary alignments being evaluated in the Environmental Impact Report and the Environmental Impact Statement. The UPRR/SR 99 Alternative is generally adjacent to the existing transportation corridor defined by the Union Pacific Railroad (UPRR) and State Highway 99 (SR99). The BNSF Alternative is essentially the same as the UPRR/SR 99 Alternative at the north and south ends of the alignment, but veers to the east to follow the BNSF Railroad corridor in the middle. Each alignment includes two options for travel to and from the San Francisco Bay Area, one along Avenue 21, the other along Avenue 24. Wye connection tracks, connecting the north-south alignments with the east-west alignments are provided to facilitate direct service between the Bay Area and Merced.

Roadway support structures associated with existing or proposed grade separations are often categorized with respect to their importance to the civilian and military transportation network. Categorization of the track support structures relative to an importance classification is not included in the 15% Design.

1.2 Merced –Fresno Section Alternatives

Merced to Fresno section of the High-Speed Train (HST) system is about 60 miles long and includes the junction that permits high-speed trains to be routed to either Sacramento or San Francisco in the north. There are three HST alternatives, the UPPR/SR 99 Alternative, the BNSF alternative, and the Hybrid Alternative (the Hybrid Alternatives is a combination of the UPPR/SR 99 Alternative and the BNSF Alternative).

The main difference between the UPPR/SR 99 and BNSF alternatives is that the UPPR/SR 99 generally follows the UPPR and the SR 99 transportation corridor that connects the cities of Merced, Chowchilla, Madera, and Fresno, whereas the BNSF Alternative follows the BNSF corridor, which travels east from Merced through Planda, Le Grand, and Madera Acres, and then veers back west to reconnect with the UPPR/SR 99 again before entering the City of Fresno. Both alternatives include design options in some areas to avoid or minimize impacts and two optional HST wye junctions (along avenues 24 and 21) that connect this section with the San

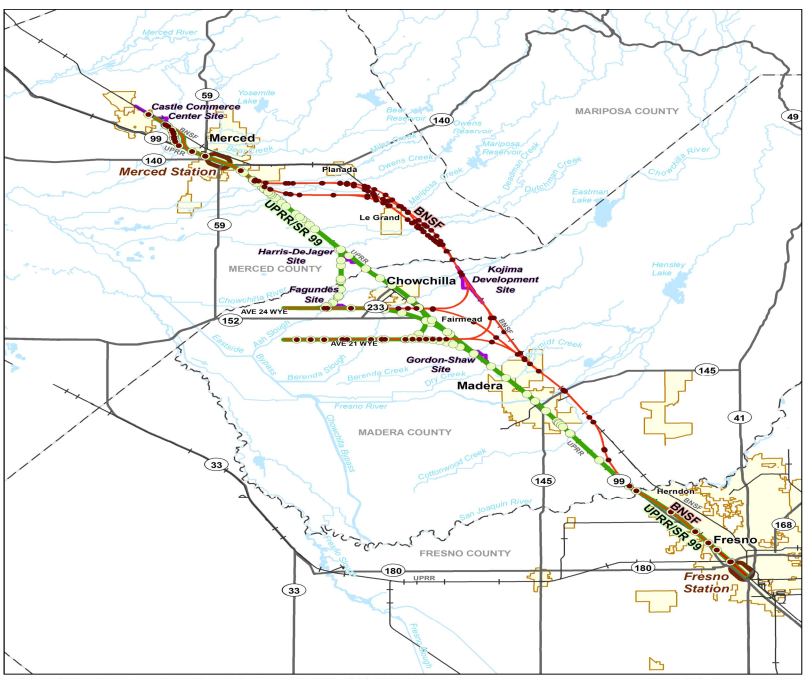
Jose to Merced Section. The route of the Merced-Fresno alignment along with various wye and design options is shown in Figure 1-1.

1.3 Report Objectives

This High Speed Train Structures Advance Planning Study (APS) has been prepared in support of the Draft 15% Design Submittal for the Merced to Fresno Section of the California High Speed Train Project..

Five volumes of HST structure APS plans for Merced to Fresno Section have been prepared and titled as follows:

1. Viaducts & Stream Crossings UPPR/SR 99 Avenue 21 Alternative
2. Viaducts & Stream Crossings UPPR/SR 99 Avenue 24 Alternative
3. Viaducts & Stream Crossings BNSF Avenue 21 Alternative
4. Viaducts & Stream Crossings BNSF Avenue 24 Alternative
5. Viaducts & Stream Crossings- Hybrid Alternative



0 9
Miles

UPRR/SR 99 Alternative
BNSF Alternative
Potential Heavy Maintenance Facility
City Limit
Station Study Area
County Boundary
Railroad
BNSF Alternative Water Crossing
UPRR/SR 99 Alternative Water Crossing

Figure 1-1
Merced to Fresno Corridor,
UPRR/SR 99 and BNSF Alternatives

1.4 Design Revisions

Recently the Merced to Fresno project team has modified the HST alignment to reduce the amount of aerial guideway required for the project. There are four areas where the alignment has been re-designed to reflect an at-grade condition.

1. Downtown Merced (including the Merced station) to south of Mission Avenue.
2. Madera Acres (Hybrid alternative)
3. North of the San Joaquin River
4. City of Fresno (South of Herndon Avenue to Clinton Avenue).

The additional length of at grade HST alignment requires modifications to several existing highway interchange approach roads and the SR99 highway in Merced. The affected roads are supported on embankment. A cut and cover design is proposed for these embankments which would create a short “tunnel” for the at grade HST guideway. The plans submitted for the 15% design effort include preliminary details of the cut and cover structures. Further refinement of these plans and details will be developed during the 30% design effort.

2.0 AERIAL GUIDEWAY VIADUCT

In general, most of elevated viaducts are assumed to be constructed using simply supported precast prestressed concrete single cell box girder superstructure elements, spanning approximately 100 to 120 feet. These structures are similar to the typical aerial viaduct structure sections in TM2.3.3. At locations requiring span lengths exceeding 130 ft, a cast-in-place balanced cantilever concrete segmental box girder is the basic structure type proposed, pending further detailed investigation. Where the proposed HST alignment crosses over a roadway or another railway at a very sharp skew, a straddle bent substructure configuration is proposed to support steel box girder with composite concrete deck superstructure to minimize impacts to roadway or railway right-of-way. For those short span stream crossings, spans typically range from 40 ft to 60 ft, precast, prestressed concrete box beams are proposed.

The aerial guideway structure will generally provide a minimum vertical clearance of 16.5 feet over existing or proposed roadways and 27 feet over railroads.

For UPRR/SR 99 Avenue 24 Alternative, a total of seven distinct aerial viaducts are proposed, with a total length of approximately 32.7 miles

- Viaduct No. 101: 54,095 feet with 492 double track spans
- Viaduct No. 102: 9358 feet with 87 double track spans
- Viaduct No. 112: 48,047 feet with 437 double track spans
- Viaduct No. 151: 36,410 feet with 332 double track spans
- Viaduct No. 161: 12,822 feet with 70 single track spans and 48 double track spans

- Viaduct No. 171: 6,270 feet with 57 single track spans
- Viaduct No. 172: 5,830 feet with 53 single track spans

For UPRR/SR 99 Avenue 21 Alternative, a total of eight distinct aerial viaducts are proposed, with a total length of approximately 30.7 miles

- Viaduct No. 101: 66,805 feet with 607 double track spans
- Viaduct No. 102: 9,358 feet with 87 double track spans
- Viaduct No. 111: 3,190 feet with 29 single track spans
- Viaduct No. 112: 57,945 feet with 527 double track spans
- Viaduct No. 121: 6,050 feet with 55 single track spans
- Viaduct No. 122: 10,290 feet with 94 double track spans
- Viaduct No. 131: 8,420 feet with 77 single track spans

For BNSF Avenue 24 Alternative, a total of eleven distinct aerial viaducts are proposed, with a total length of approximately 13.4 miles

- Viaduct No. 2: 15,258 feet with 139 double track spans
- Viaduct No. 3: 7,140 feet with 92 double track spans
- Viaduct No. 11: 2,310 feet with 21 double track spans
- Viaduct No. 12: 2,310 feet with 21 single track spans
- Viaduct No. 13: 6,600 feet with 60 double track spans
- Viaduct No. 14: 9,130 feet with 83 double track spans
- Viaduct No. 51: 8,650 feet with 73 double track spans
- Viaduct No. 52: 913 feet with 8 double track spans
- Viaduct No. 71: 9,145 feet with 83 double track spans
- Viaduct No. 72: 3,960 feet with 36 single track spans
- Viaduct No. 81: 5,057 feet with 46 single track spans

For BNSF Avenue 21 Alternative, a total of nine distinct aerial viaducts are proposed, with a total length of approximately 11.9 miles

- Viaduct No. 1: 5,515 feet with 51 double track spans
- Viaduct No. 2: 16,170 feet with 147 double track spans
- Viaduct No. 3: 7,140 feet with 92 double track spans

- Viaduct No. 11: 2,310 feet with 21 double track spans
- Viaduct No. 12: 2,310 feet with 21 single track spans
- Viaduct No. 13: 6,600 feet with 60 double track spans
- Viaduct No. 14: 9,130 feet with 83 double track spans
- Viaduct No. 21: 9,329 feet with 85 single track spans
- Viaduct No. 22: 4,400 feet with 8 single track spans

For Hybrid Alternative, a total of seven distinct aerial viaducts are proposed, with a total length of approximately 4.9 miles

- Viaduct No. 201: 5,095 feet with 47 double track spans
- Viaduct No. 203: 9,798 feet with 91 single track spans
- Viaduct No. 211: 3,410 feet with 31 single track spans
- Viaduct No. 221: 3,740 feet with 34 single track spans
- Viaduct No. 222: 3,830 feet with 35 single track spans

2.1 Description of Alternatives

As shown in Figure 1, the Merced to Fresno Section of the HST System would connect the central San Joaquin Valley region to the rest of the statewide HST System, specifically to (1) the San Jose to Merced Section via Pacheco Pass, (2) the Merced to Sacramento Section to the north, and (3) the southern Central Valley and Southern California sections of the statewide HST System. There are two north-south alignment alternatives (UPRR/SR99 and BNSF) providing a route between Merced and Fresno. These alternatives would be combined with two east-west alignment alternatives (Avenue 21 and Avenue 24) that provide service to the Bay Area. There is also a Hybrid alternative that combines elements of both north-south alternatives with the Avenue 24 alignment.

2.1.1 UPRR/SR99 Alternative

The north-south alignment of the UPRR/SR99 alternative would traverse approximately 57 miles between Downtown Merced and Downtown Fresno, crossing portions of Merced, Madera, and Fresno counties through the Cities of Merced, Chowchilla, Madera, and Fresno.

The UPRR/SR 99 Alternative would begin at the Downtown Merced HST Station and would generally run parallel to SR 99 and the UPRR from Merced to Fresno. From Merced to the City of Chowchilla, the alignment would run parallel with and west of SR 99 and the UPRR right-of-way. North of downtown Chowchilla, SR99 veers away from the UPRR toward the east. The HST alignment would cross over to the east side of the UPRR and align with the west side of SR99. South of downtown Chowchilla, near the town of Fairmead, SR99 crosses over the UPRR. Near this area the HST alignment crosses over SR99 and aligns with the east side of the UPRR

right of way. The HST alignment continues along this alignment through the City of Madera until crossing the San Joaquin River into Fresno County.

The UPRR/SR 99 Alternative would generally be straight and at-grade in rural areas. In areas where the alignment would travel near the city centers of Merced, Chowchilla, Madera, and Fresno, elevated guideways would be used to minimize impacts on the local roadway network.

The Avenue 21 alignment will follow along the north side of the Avenue 21 right of way to Road 14. Near Road 15, the wye connection tracks would diverge from the main line tracks to connect to the north-south alignment toward Merced.

The Avenue 24 alignment will follow along the south side of Avenue 24 to Road 8. Near Road 9, the wye connection tracks would diverge from the main line tracks to connect to the north-south alignment toward Merced.

A variation of the Avenue 24 alternative, the West Chowchilla Design Option (WCDO), would eliminate the main line track between Fairmead and the north end of Chowchilla. Access to Merced from Fresno would be provided via a new curve connecting the Avenue 24 alignment with the wye connection alignment along Avenue 12.

2.1.2 BNSF Alternative

The BNSF Alternative would generally follow the BNSF Railroad alignment from Merced to Fresno, for an approximate length of 61 miles between the Downtown Merced and Fresno Stations. This alternative would begin at the same Downtown Merced Station as the UPRR/SR99 Alternative. South of Merced, the alignment would turn east, following either the Mission Avenue or Mariposa Avenue alignments toward the town of Le Grand. The HST alignment would then turn south and align with the BNSF just north of Le Grand.

South of Le Grand, the BNSF alternative would travel along the west side of the BNSF right of way, through Madera Acres, an unincorporated community in Madera County. South of Madera, the BNSF Alternative would transition back toward the UPRR corridor just north of the San Joaquin River and cross over the river. The alignment south of the river would be the same as the UPRR/SR99 Alternative to the Downtown Fresno Station, as described above.

As with the UPRR/SR 99 Alternative, the BNSF alternative would also include both the Avenue 21 and Avenue 24 alignments to provide service to the Bay Area. The alignments would be identical in relation to the existing street rights of way and end points.

For the Avenue 21 alignment, the wye connection tracks would diverge from the main line tracks near Road 20 in order to connect to the north-south alignment toward Merced. For the Avenue 24 alignment, the wye connection tracks would diverge from the main line tracks near Road 17.

2.1.3 Hybrid Alternative

The Hybrid alternative combines elements of the UPRR/SR99 and BNSF alternatives with an additional wye connection near Chowchilla. Between Merced and Chowchilla the alignment would follow the UPRR/SR99 alignment to the point where the Avenue 24 wye connection tracks meet the UPRR/SR99 alignment (near South Athlone Road). The alignment would then follow the Avenue 24 wye connection track alignment, then turn east and follow the Avenue 24 alignment. From this point the alignment would follow the BNSF Avenue 24 alternative through Madera Acres and into Fresno. The alignment toward the Bay Area would be identical to the Avenue 24 alignments for both the UPRR/SR99 and BNSF alternatives.

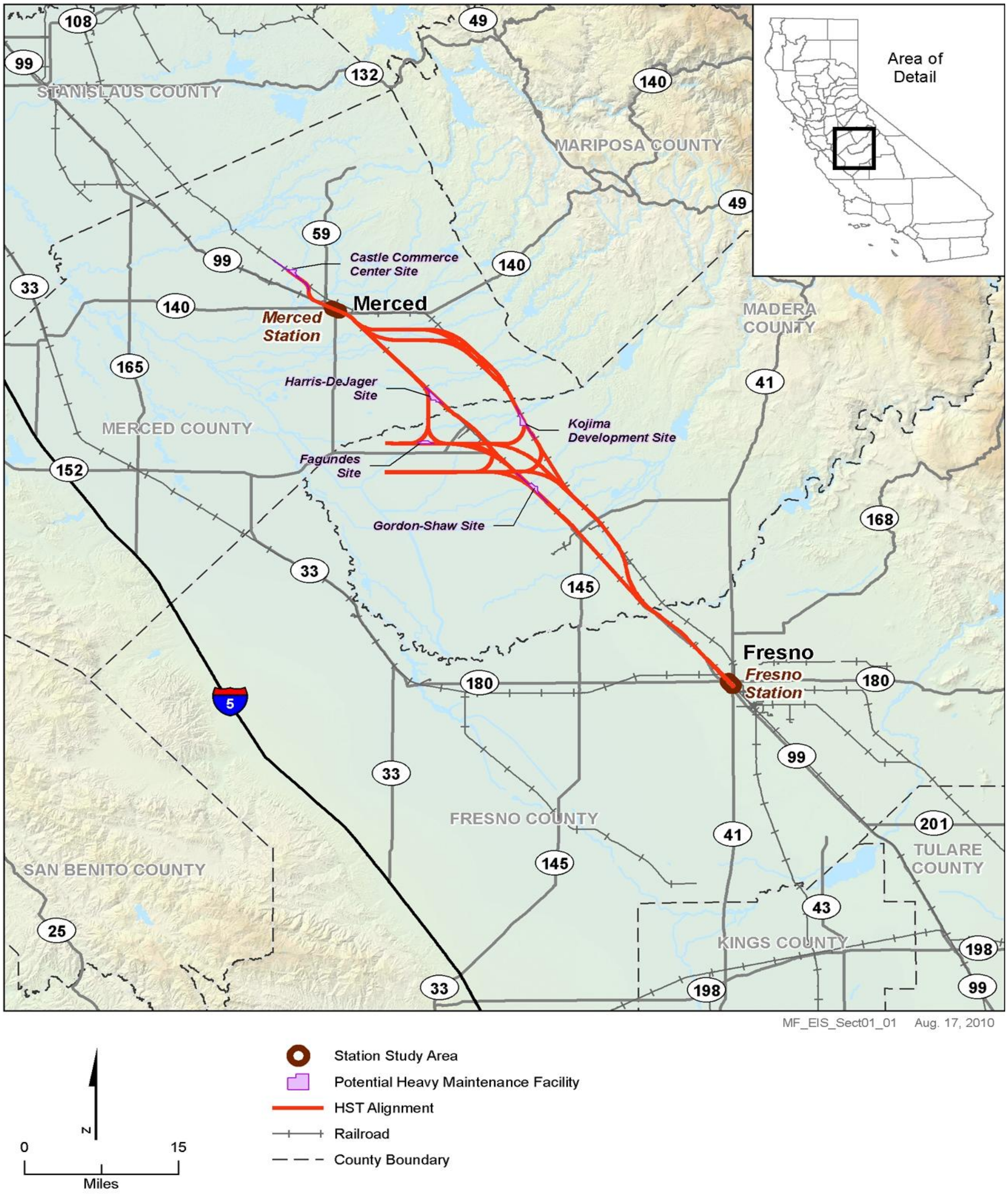


FIGURE 2 – ALIGNMENT ALTERNATIVES

2.2 Design Assumptions and Considerations

The primary purpose of the 15% engineering design is to support EIS/ERS process via assessing the possible and potential maximum environmental and R/W impacts that could be induced by the proposed viaduct construction, with a focus on feasibility, constructability and economy. The goals in laying out the viaduct foundations are to (1) avoid conflicts with existing and planned transportation features that are present along the alignment such as; freight/passenger rail tracks, interstate highways, and major state and municipal roads and boulevards, (2) minimize impacts hydrologic/hydraulic features such as existing streams, canals, river, etc., (3) balance span lengths, and facilitate (4) superstructure erection methods.

Available aerial survey images and data were used as both the background and geometric basis during the development of the proposed configurations in conjunction with the design horizontal and vertical alignments. During the development of the 15% design, it has become clear that a great deal of new development had occurred along the corridor and more site specific survey program needs to be developed. Once accepted and approved, the program will be carried out to confirm the proposed foundation locations with improved and enhanced surveying accuracy. Adjustments to pier/foundation locations are therefore envisioned in the 30% design stage. Such necessity is expected in order to achieve optimal span layout and formalize a baseline performance benchmark for the anticipated design/build contract documents preparation.

It has been assumed all commercial/residential/industrial buildings that are located directly below the viaduct will be demolished to satisfy system wide operation intrusion protection requirements.

2.2.1 Guideway Girder Consideration

It must be recognized that TM 2.3.3 was released to provide some guidance for 15% design of aerial viaduct guideway, without implicit characteristics of the system vehicle that will eventually be used for the CHST. Thus, its application was interpreted for this level of design to provide reasonably conservative cost estimates without the necessity to design the Guideway girders. Further, from experience designing structures for high speed trains, the dynamic responses (such as train impact forces, resonance, track structure interaction, and riding comfort issues as well as seismic performance) will govern design, but not enough information is available at this time for these specific areas. It is further recognized that design will be required for the 30% level consistent with a Type, Size, and Location Study that requires enough detail to quantify seismic response, concrete, prestressing forces, reinforcing steel, foundation types and sizes, excavation and backfill, number, location and sizes of bearings, locations of structure expansion joints, as well as other items.

A depth (D) to span (S) ratio of 1 to 9 to 1 to 11 has been used in the high speed rail systems throughout Europe and Asia. For this design effort a 1 to 10 (D/S) ratio, also as prescribed in TM 2.3.3, is adopted for the typical standard spans of 110 ft. To create an appealing exterior profile, a constant girder depth of 11 ft is used system wide, even for much shorter spans. Preliminary analysis of the aerial viaducts that the design of primary member size is most situations will be governed by service requirements, such as the limiting frequency response or deflection limitations for ridership comfort and safety.

Closed single cell box type as depicted in TM 2.3.3, Figure 6-1, is shown on the drawings to represent a feasible girder configuration. Such a girder configuration is chosen for consistency with TM 2.3.3 to support both dual tracks and single track train movement for the 15% level.

At few locations where longer spans are unavoidable, the design of a concrete girder erected by the balanced cantilever method of construction can be achieved; such as for spans 130 ft to 260 ft in this project. These would generally be cast-in-place segmental construction utilizing form travelers. While falsework columns are generally not necessary when implementing this type of construction technique, allowing unimpeded access below the bridge, the temporary vertical clearance is typically reduced by a few feet to accommodate the underhanging traveler. The absence of falsework framing is especially important when constructing bridges over waterways with navigation issues, sensitive biological resources and/or roadways with high traffic volumes requiring large falsework openings.

Heights of approach fills for the aerial structures have been assumed to be 25 ft to 30 ft for the preliminary design. An evaluation of costs associated with fill heights up to 40ft will be made during the 30% design for comparison with cost of aerial structure to determine a guideline for the appropriate transition point.

To avoid impact to UPRR/SR99, series of straddle bents will be required to clear 100 feet operational right-of-way for the UPRR while managing structure span lengths to the reasonable range of 100 to 110 feet. A steel superstructure twin box girder is an option for this condition, because its lighter weight allows longer spans.

For short-span water crossings, prestressed, precast box beams are proposed. Preliminary analysis indicates that the proposed structure depth can be less than D/S ratio of 1/10 and the structure still meets the deflection limitations for ridership comfort and safety.

2.2.2 Substructure/Foundation Considerations

The level of the 15% design effort was limited. No detailed structural design was performed. Preliminary analyses indicate that for a double track super-structure, a single 10 foot diameter column, supported on a single 12 foot diameter cast-in-drilled-hole (CIDH) pile will provide adequate substructure stiffness to meet the current design criteria requirements. Large diameter CIDH pile foundations have been used successfully for highway and railway structure foundations throughout the State of California.

The following loads are considered in assessing the column sectional dimensions and the supporting foundation sizes:

- Two feet thick equivalent ballast track load.
- AREMA longitudinal and transverse load criteria with Cooper E50 equivalent loads. Number of wheel loads within a typical span was rationalized to achieve meaningful loading on the substructures.
- Static equivalent approach and column plastic hinging capacity are used as seismic design consideration. The foundation types and CIDH shafts are

determined by 120% plastic hinge moment capacity of the columns, along service design load.

a) Foundation Type:

Various foundation types including concrete and steel piles have been studied and evaluated. Since the alignment corridor is situated along corridors which are highly urbanized, the use of driven piles is currently not recommended. AECOM's geotechnical sub-consultant has collected available existing soil boring logs from agencies that originate from projects implemented near or adjacent to the alignment corridor. Most of the logs of borings were located within one mile from the track alignment. However, this data is for preliminary reference and design only.

CIDH piles of various diameters have been constructed extensively for highway foundations in the State of California. Geotechnical recommendations are very limited at this stage of the design; therefore very approximate assumptions have been made regarding expected pile capacity, foundation stiffness, etc. Based on the preliminary soil data collected this type of foundation is considered the preferred foundation type to support the aerial viaduct structures. Mono-shaft, 12ft in diameter has been considered and shown in the plans. Pile lengths ranging between 90ft and 125ft were assumed in the foundations in relation to the viaduct profiles.

b) Substructure:

Two typical column shapes are considered: circular columns or hollow rectangular columns. The size of columns is assumed 10' diameter to provide the support for the structure. For column heights greater than 100', a large rectangular hollow column is proposed which tapers from its top. Additional frequency analysis was performed to confirm the proposed sizes of the tall column meet the frequency requirement per Technical Memorandum -Track-Structure Interaction (TM 2.10.10)

2.2.3 Seismic Design Considerations

No portion of the project alignment is within a State of California Alquist-Priolo Earthquake Fault Zone, and no active faults are known to cross the alignment. Therefore, the risk of fault rupture occurring across the alignment of the segment under consideration is considered low.

The strongest ground shaking at the project area is expected to be as a result of an earthquake originating on the San Andreas Fault (Mmax-7.9) or the Ortigalita Fault (Mmax=7.1) at a distance of about 60.7 miles and 36.1 miles, respectively. Both of these faults can produce peak horizontal ground acceleration (PGA) of approximately 0.06g at the project site based on our preliminary evaluation. This potential ground motion value is relatively low compared with more active regions of California.

Based on the California High-Speed Train Project technical Memorandum: 15% Seismic Design Benchmarks (TM 2.10.5) dated March 15, 2010: in the absence of any project specific seismic design criteria, designers are directed to United States Geological State Geological Survey (USGS) Earthquake Hazards Program. Design Maximum Considered Earthquake (MCE) spectra were developed based on the Site Class D.

Preliminary seismic analysis of a typical aerial viaduct span indicates that the apparent seismic demands will not be significant while comparing to the serviceability requirements of the structure.

2.2.4 Construction Costs

An engineer's opinion of construction cost will be developed after submittal of the final 15% design package